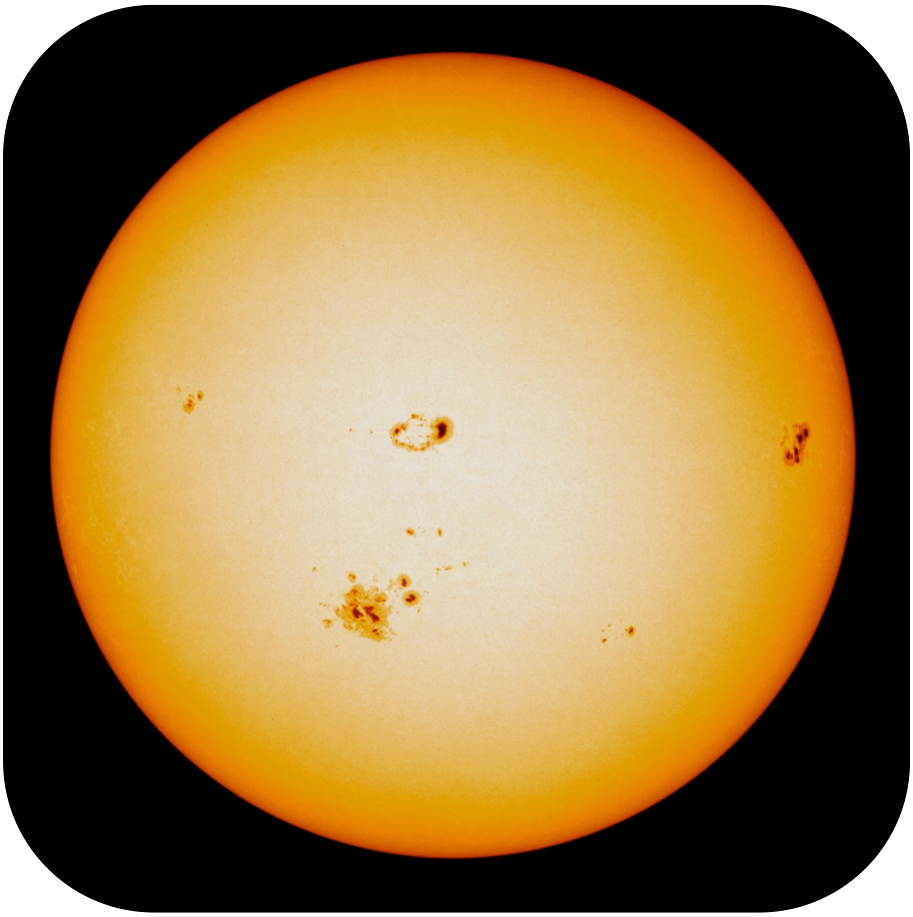
Sun’s differential rotation

Student’s Guide – Basic Level

CESAR’s Science Case



Introduction

Unlike the Earth, the Sun is not a rigid body. As it's a non rigid body, different parts of the Sun may rotate at different speeds, and they actually do so. In this laboratory you will study the differential rotation of the Sun by measuring the rotating speed of multiple sunspots. As the CESAR team at ESAC has a solar observatory (CESO) constantly monitoring the Sun, there's no need to request observation time in the observatory, you can just use the on-line images that seem good to do the measurements successfully.

Material

What will you need?

- The Sun's differential rotation Student's Guide.
- Computer with Web Browser and Internet Connection.
- Access to CESAR web tools.

Background

The Earth constantly rotates about it's axis, in the same way as a carousel does. This rotation is the reason for day and night. Check it in this video.

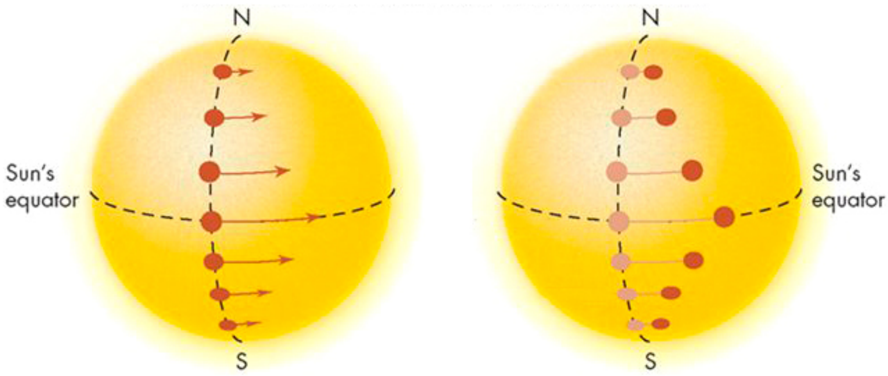
youtube.com/watch?v=GI3rBwqwDbw

Like the Earth, the Sun rotates too. You can see it in this other video.

youtube.com/watch?v=oaBjfsouIao

The features in Sun's surface rotate together with the Sun, so if we measure how fast this features rotate, we will know how fast the Sun rotates. The problem is that depending on where in the Sun the feature is, it may move slower or faster. Why?

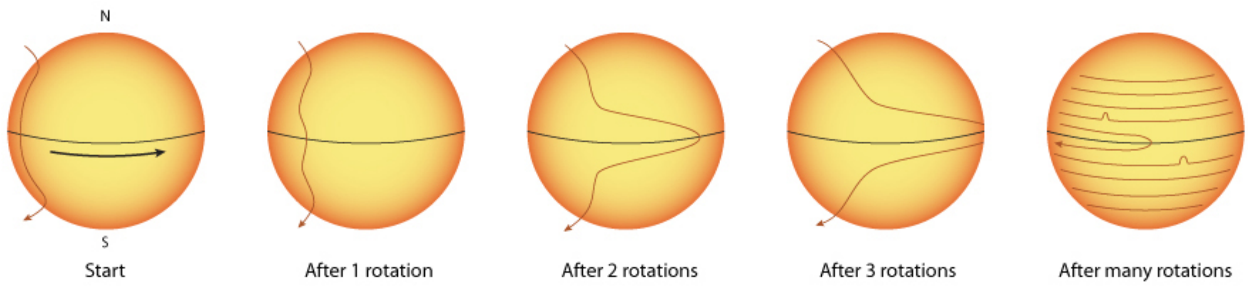
Unlike the Earth, **the Sun is not a rigid body**. This means that when studding the movement of the Sun, you can not consider it as a compact structure. The sun is actually a massive sphere of plasma, more similar to a huge ball of gas than to a solid rigid structure. This is no different to soil and water. Soil is a solid structure, but water is not. You may have water moving at different speeds than the water near by, like a sea current. That's because water is not a rigid body, water is not attached to anything and it's free to move anywhere. Same thing happens with the plasma in the Sun.



Credits: McGraw-Hill

Unlike in Earth, **not every point of the Sun's surface rotates at the same speed**. In the Earth every point in the surface rotates at the same speed, in the Earth a day last 24h in everyplace, because the whole Earth moves together. But as the Sun is not a rigid body, but more like water, **nothing forces the Sun surface to move has a whole. The plasma located in different places of the surface may rotate at different speeds, that is what we call differential rotation.**

In fact, after many observations, it has been stated that Sun poles rotate slower than the equator. Actually, **in the Sun, the closer to the poles you get, the slower the surface rotates**. So every point in the Sun's surface rotates at a different speed. The Sun rotates really fast at the equator and it slows down when moving towards the poles. This differential rotation is what we are checking in this laboratory.



Credits: NASA / IBEX

Laboratory Execution

We are calculating the rotation speed of the Sun by measuring the speed of sunspots in Sun's surface. Our point is to study the differential rotation of the Sun, so we'll have to locate one sunspot close to the equator and an other one as far away as possible. Once we locate them, we'll calculate their speeds (which is also the rotation speed of the Sun) and check if they really are different.

In the CESAR web tool, the equator line is the one marked in a different colour. You must use the displayed calendar to look through different days until you find a picture that has a sunspot at the equator.

The Sun is always moving, so once you locate a sunspot, you will realise that if you choose an image from the previous day, the sunspot will appear moved to the left. In the same way, if you choose an image from the next day, the sunspot will move to the right. **What we actually want to do, is select two images, separated by two or more days, so that in one of them the sunspot is at the left, and in the other one in the right. By measuring how much the sunspot moved in those days, we will know how fast it is moving.** Mark the positions of the sunspots in each day and the program will calculate the speed of the sunspot.

Once you got the speed of the first sunspot, you will have to find a second one, further away from the equator, to check if it moves slower. Use the calendar again, go through a few months and choose a sunspot as far away as possible. Again choose two images of the same sunspot separated by a few days and measure de distance as you did before.

And that is it! Now you know the speed of a sunspot close to the equator and the speed of a sunspot close to the poles, and you can compare and see which ones is bigger.

Conclusions

In this laboratory you have studied Sun's differential rotation. You've calculated Sun's rotation speed in the equator and close to the poles. For doing so you tracked the movement of two different sunspots in time-spaced images and calculated their speed by measuring how much they moved between the images.

When doing science, it's always a good idea to check your results before publishing them. As you know from the images in the background section, the Sun's rotation speed is higher in the equator than closer to the poles. Does this agree with your calculations? Did you get a faster speed in the equator?

If you do have obtain a consistent value, lets go one step further, if you had to guess, how fast would you say a sunspot located between the two you looked at would move?